The Sustained Ocean Observing System for Climate System Management

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Project Summary

Introduction

The Office of Climate Observation (OCO) is a project office established in 2003 under the auspices of the Climate Program Office (CPO) to manage the ocean sub-capability of the Climate Observations and Analysis Program. NOAA's Climate Goal, via the OCO, provides the backbone of the Global Component of the U.S. Integrated Ocean Observing System (IOOS). IOOS is the U.S. contribution to the international Global Ocean Observing System (GOOS), which is the ocean baseline of the Global Earth Observation System of Systems (GEOSS).

It is the job of OCO to advance the multi-year *Program Plan for Building a Sustained Ocean Observing System for Climate*. The intended outcome is a sustained global system of complementary *in situ*, satellite, data, and modeling subsystems adequate to accurately document the state of the ocean and to force climate models. The observing system is being put in place to meet climate requirements but it also supports weather prediction, global and coastal ocean prediction, marine hazard warning systems (e.g., tsunami warning), transportation, marine environment and ecosystem monitoring, and naval applications. Many non-climate users also depend on the baseline composite system that is nominally referred to as the sustained ocean observing system for climate.

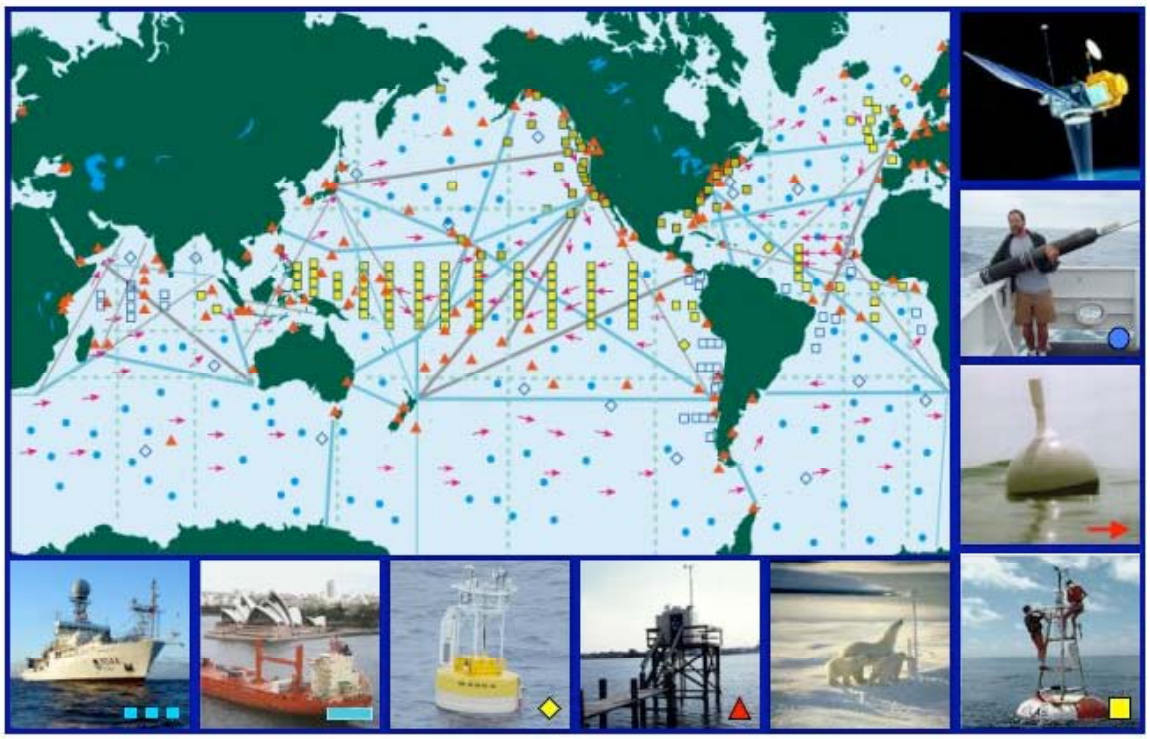

Figure 1. The Networks that make up the Sustained Ocean Observing System for Climate are (from lower left to upper right): Dedicated Ships, Ships of Opportunity, Ocean Reference Stations, Tide Gauge Stations, Arctic Observing Systems, Tropical Moored Buoys, Surface Drifting Buoys, Argo Profiling Floats, and

Continuous Satellite Missions for sea surface temperature, sea surface height, surface vector winds, ocean color, and sea ice. Not illustrated are the Data & Assimilation Subsystems and Product Delivery.

Responsible Institutions

The "Networks" are managed by 19 distributed centers of expertise at the NOAA laboratories, centers, joint institutes, universities and business partners. The "System" is centrally managed at the Office of Climate Observation. Specifically, OCO's tasks are to:

- Monitor the status of the globally distributed networks; report system statistics and metrics routinely and on demand;
- Evaluate the effectiveness of the system; take action to implement improvements through directed funding;
- Advance the multi-year program plan; evolve the *in situ* networks through directed funding;
- Focus intra-agency, interagency, and international coordination;
- Organize external review and user feedback; and
- Produce annual reports on the state of the ocean and the adequacy of the observing system for climate.

The distributed centers of expertise that are implementing NOAA's contributions to the system are at AOML, PMEL, ESRL, GFDL, JIMAR (University of Hawaii), JIMO (Scripps Institution of Oceanography), CICOR (Woods Hole Oceanographic Institution), JISAO (University of Washington), CIMAS (University of Miami), CICAR (Columbia University), NCDC, NODC, NGDC, CO-OPS, NMAO, NDBC, NCEP, FSU (Florida State University), and CLS America. The contributions of these centers are summarized by the project managers in their individual reports.

Across NOAA there are 45 Federal employees, and 105 non-Federal employees working to implement the system. Within the OCO project office there are four Federal employees, and four non-Federal; one of the OCO Federal employees is detailed to the JCOMM Secretariat at the international GOOS Project Office at IOC/UNESCO in Paris.

Partnerships are central

A global observing system by definition crosses international and institutional boundaries, with potential for both benefits and responsibilities to be shared by many. In addition to the work specifically supported through the OCO program, NOS, NMFS, and NWS maintain observational infrastructure for ecosystems, transportation, marine services and coastal forecasting that do or have potential to contribute to climate observation. NOS sea level measurements in particular provide one of the best and longest climate records existent. NESDIS data centers are essential. NMAO ship operations are necessary for supporting ocean work. NESDIS and NPOESS continuous satellite missions are needed to provide the remote sensing that complements the *in situ* measurements. All of the OCO contributions to global observation are managed in cooperation internationally with the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). The National Science Foundation has initiated their Ocean Observatories Initiative, which will potentially provide significant infrastructure in support of ocean climate observation. The ongoing NSF-NOAA cooperative project for CLIVAR-ocean carbon surveys has proved to be an interagency-international-interdisciplinary success. The Office of Naval Research maintains a GODAE data server at Monterey that is critical to global data access. The UNOLS fleet provides ship support for ocean operations. NASA's development of remote sensing techniques is key. The ocean climate research being conducted by the CPO science programs, other NOAA programs, NASA, NSF, and the Navy provides the advancements in knowledge that are essential for continuous system improvement.

Mission and Requirements

The mission of the OCO is to build and sustain a global climate observing system that will respond to the long term observational requirements of the operational forecast centers, international research programs, and major scientific assessments. The focus is on building the *in situ* ocean component. The top-level requirements are to:

- document long term trends in sea level change;
- document ocean carbon sources and sinks;
- document the ocean's storage and global transport of heat and fresh water; and
- document ocean-atmosphere exchange of heat and fresh water.

Deliverables

The ocean climate observing system must have the capability to deliver continuous instrumental records and analyses accurately documenting:

- Sea level to identify changes resulting from climate variability;
- Ocean carbon content every ten years and the air-sea exchange seasonally;
- Sea surface temperature and surface currents to identify significant patterns of climate variability;
- Sea surface pressure and air-sea exchanges of heat, momentum, and fresh water to identity changes in forcing function driving ocean conditions and atmospheric conditions;
- Ocean heat and fresh water content and transports to: 1) identify changes in the global water cycle; 2) identify changed in thermohaline circulation and monitor for indications of possible abrupt climate change; and 3) identify where anomalies enter the ocean, how they move and are transformed, and where they re-emerge to interact with the atmosphere; and
- Sea ice thickness and concentrations to identify changes resulting from, and contributing to, climate variability and change.

Present ocean observations are not adequate to deliver these products with confidence. The fundamental deficiency is lack of global coverage by the *in situ* networks. Present international efforts constitute only about 56% of what is needed in the ice-free oceans and 11% in the Arctic. The *Second Report on the Adequacy of the Global Observing System for Climate in Support of the UNFCCC* concludes that "the ocean networks lack global coverage and commitment to sustained operations…Without urgent action to address these findings, the Parties will lack the information necessary to effectively plan for and manage their response to climate change."

In response to the Second Adequacy Report, international GCOS produced the *Implementation Plan for the Global Observing System for Climate in support of the UNFCCC* (GCOS-92). GCOS-92 was published in October 2004. It has been endorsed by the UNFCCC and by the Group on Earth Observation (GEO). In particular:

1. The UNFCCC, Decision CP.10, "Encourages Parties to strengthen their efforts to address the priorities identified in the [GCOS] implementation plan, and to implement the priority elements …"
2. The *Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan Reference Document* targets include: "Support implementation of actions called for in GCOS-92."

OCO's *Program Plan for Building a Sustained Ocean Observing System for Climate* is in complete accord with GCOS-92 and provides the framework for NOAA contributions to the international effort. In particular 21 of the specific actions listed in the GCOS-92 ocean chapter (pages 56-84) are being acted upon by the OCO program in cooperation with the implementation

panels affiliated with the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). These specific GCOS-92 actions now provide an excellent roadmap to guide observing system workplans. GCOS-92 is accessible via link from the OCO web site: www.oco.noaa.gov -- click on "Reports & Products." All of the work supported by OCO is directed toward implementation of this international plan and the projects are being implemented in accordance with the GCOS Ten Climate Monitoring Principles. The OCO supported projects contributed nearly half of the total international effort in 2006.

FY 2006 Accomplishments

The international global ocean climate observing system overall advanced from 55% complete in FY 2005 to 56% complete in FY 2006.

The OCO program was reviewed 10-12 May 2006 in Silver Spring. The Annual System Review brought together 115 project managers, data users, advisors, and program managers both from NOAA and from other partner institutions to discuss system-wide issues and engage in program strategic planning. Several international program managers and technical coordinators associated with the JCOMM Observations Coordination Group (OCG) and the JCOMM Observing Platform Support Centre (JCOMMOPS) attended the meeting, bringing international expertise and advice to the OCO program. External review of the program was provided by the Climate Observing System Council (COSC).

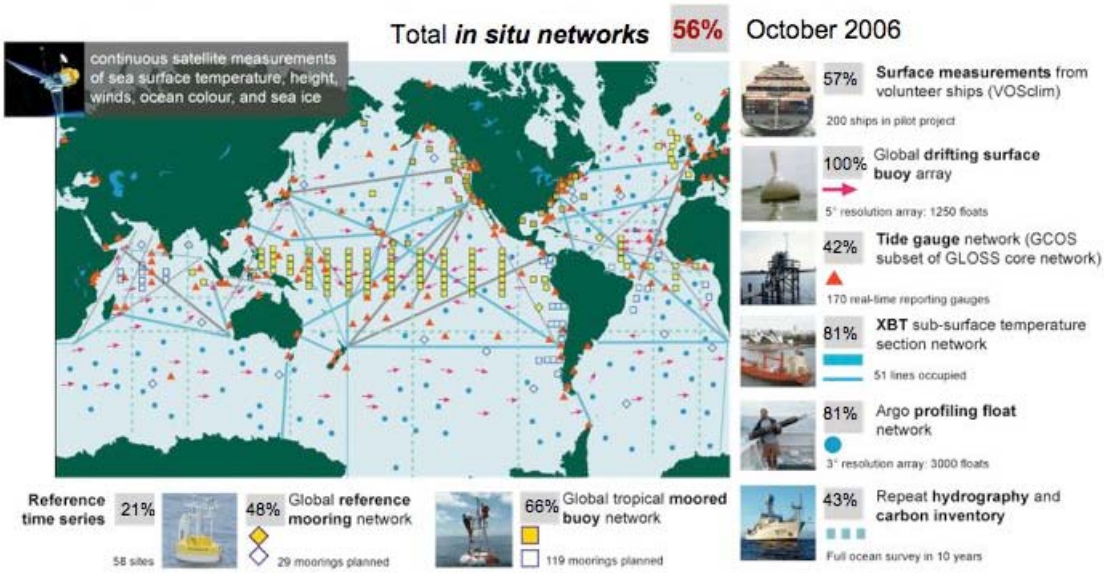

Figure 2: A schematic of the initial composite ocean observing system, including the current status against the targets of JCOMM and the GCOS Implementation Plan (GCOS-92).

The annual reports of the Project Managers detail the specific advancements of the individual networks. Highlights for 2006 include:

- *Documenting long-term trends in sea level change*: Following the tragic Indian Ocean tsunami of 24 December 2004, tide gauge station upgrading to real-time reporting continued to be the top priority for the sea level program, so that the climate stations contribute to the international tsunami warning system as well as to the climate reference network.

- *Documenting the ocean-atmosphere exchange of heat and fresh water*: The Global Drifting Buoy array was maintained at its design goal of 1250 buoys in sustained service. FY2006 was the first full year of operations at the system design level. The Tropical Moored Buoy network was expanded in the Atlantic Ocean; the U.S. added two new stations in the PIRATA North East Extension off the west coast of Africa. In cooperation with Chile, the Stratus Ocean Reference Station project installed a U.S. surface meteorology sensor suite on the Chilean tsunami warning buoy; this was the first multi-use ocean station established through cooperation of the international OceanSITES program and the international tsunami warning systems.
- *Documenting the ocean's storage and global transport of heat and fresh water*: The Argo array continued its rapid progress toward global coverage, passing the milestone of 2500 active floats in service. Transition of the MOVE array from Germany (research investigation) to U.S. support (sustained time series) was initiated. Transition of the Indonesian Through Flow monitoring system from NSF to NOAA funding was initiated. Development of the California Current near-real-time monitoring system was initiated.
- *Documenting ocean carbon sources and sinks*: Two carbon dioxide monitoring systems were added to the Ocean Reference Stations at the Hawaii Ocean Time-series site and the Bermuda Test bed site.
- *System management and product delivery*: The reporting of oceanic essential climate variables was advanced, with the Bulletin of the American Meteorological Society (BAMS) annual *State of the Climate* special edition publishing eight articles on the state of the ocean. The test Version 2.00 Beta of the Observing System Monitoring Center web tool was made available to the international community via the JCOMMOPS web site as well as the OCO web site.

Global Ocean Observing System Budget Allocation ($K)					
Network	**FY 02**	**FY 03**	**FY 04**	**FY 05**	**FY 06**
Tide Gauge Stations	670	710	970	1196	1177
Drifting Buoys	1699	2077	2769	3130	3427
Tropical Moored Buoys	3175	3175	3625	4360	3094
Ships of Opportunity	1960	1903	2487	2907	2776
Argo Profiling Floats (gliders)	271	275	273	249	247
Ocean Reference Stations	1712	2082	2998	2995	3958
Ocean Carbon Networks	1478	2204	2875	3521	3482
International Arctic Ocean Observing System	337	337	337	397	310
Dedicated Ship Time	0	626	523	92	542
Data & Assimilation Subsystems	1286	1323	1487	1418	1331
Service Argos Data Processing	813	480	1525	1408	448
Product Deliver, Analysis/Reanalysis	578	638	896	1982	2048
Institutional Infrastructure	626	653	1269	1356	711
IOOS Global Systems Total (OCO managed)	**14605**	**16483**	**22034**	**25011**	**23551**
Partner Programs					
Argo Program (managed separately)	6978	9706	9811	9491	9758
Arctic Program (managed separately)	1600	4322	3651	4928	4927
TAO/PIRATA, NWS operations (managed separately)	0	0	0	0	3200
OCO Funding Distribution					
NOAA				13944	12388
External				9043	10301
CLS America				1408	448
Community Support (workshops, panels, JCOMM, CLIVAR, GOOS)				616	414
Total Global Systems, OCO managed				**25011**	**23551**
OCO Income Budget Lines					
OAR Laboratories & Cooperative Institutes				5613	5389
OAR Climate & Global Change Program				4886	4619
OAR Climate Observations & Services				14156	9871
NWS TAO/PIRATA					2695
Other (one-time supplemental funding)				356	977
Total				**25011**	**23551**

Table 1: System Funding Record